CONTROL

SYSTEMS · INSTRUMENTATION · DATA PROCESSING · ENGINEERING · APPLICATIONS

A TECHNICAL JOURNAL FOR DESIGNERS AND USERS OF ELECTRICAL, ELECTRONIC, HYDRAULIC, MECHANICAL AND PNEUMATIC CONTROL SYSTEMS AND INSTRUMENTATION

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EMERGENCY ISSUE

As most readers will know, there is at present a dispute in the printing industry which has made the publication of a normal magazine impossible. However by eliminating a certain amount of editorial and advertising we have been able to produce this emergency issue.

As publishers we are not parties to the dispute and we apologize to readers and advertisers for any inconvenience caused.

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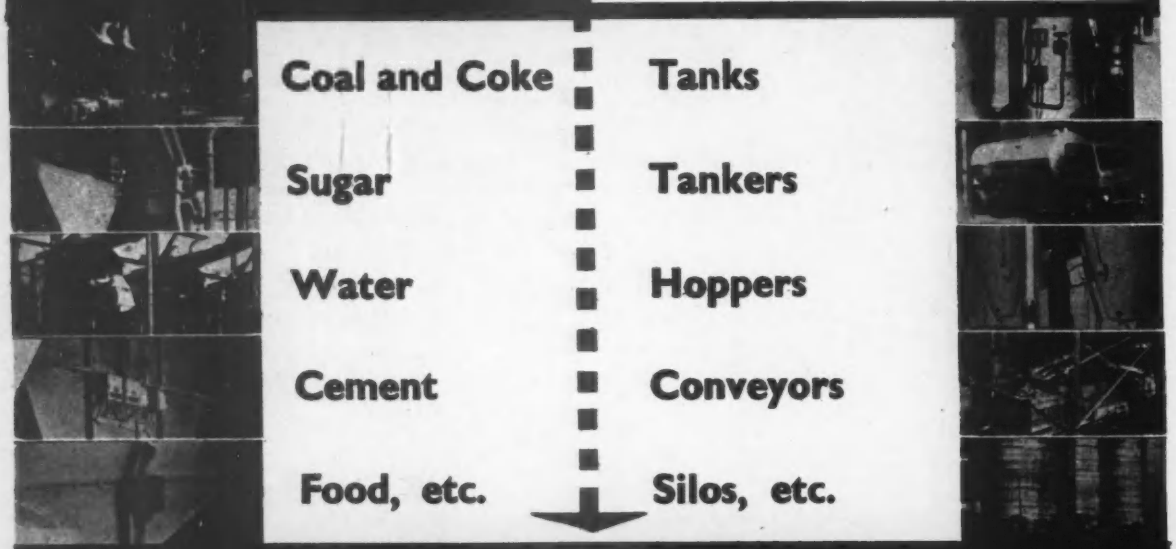

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Sir! LETTERS TO CONTROL

IMechE opposes National Control School

SIR: As requested by you, the article in the March issue of CONTROL on the need for a National Control School has been submitted to our Education Committee.

The item gave rise to a fairly long discussion. The outcome however was that the Committee felt that, at the present time, there was no need for the establishment of a special National School for this subject. It was thought that there were not only a large number and wide variety of short postgraduate courses on control available at colleges, but, in addition, several universities were now including automatic control in their first degree and postgraduate courses.

As you may know, this Institution recently arranged, in conjunction with the Cambridge University Engineering Department, a Conference on Teaching the Fundamentals of Automatic Control for teachers in Universities and Colleges of Advanced Technology.

I was asked by the Committee to thank you for drawing their attention to the article and to let you know that the Institution is keenly interested in all developments in this field, and, as a member of the BCAC will continue to take an active part in those developments.

Secretary, The Institution of Mechanical Engineers
B.G. ROBBINS

EIA backs it

SIR: May I comment briefly on the letter from 'Don Servo' in your May issue?

Your correspondent considers that industry must not expect the Government to shoulder all the responsibility for a National Control School and urges, with reason, that industry itself must be prepared to contribute, in particular by: (1) allowing employees the necessary time to attend courses; (2) providing equipment and examples of the application of control techniques; (3) financial support for associated research.

Whilst one could hardly quarrel with these three propositions, your correspondent appears to assume that courses at the School would be for the exclusive benefit of postgraduates. At the present time, I would put the prime necessity as the indoctrination of top management in new control techniques, since unless company directors understand the importance of them, the general support of industry will not be forthcoming nor will industry strive to recruit first-class control engineers. The first problem for the National Control School is likely to be whether it can induce directors to attend short courses. Control engineering is still often considered as a purely technical subject, whereas in fact its adoption by industry is highly conditioned by capital and labour problems. Thus the EIA considers that the education of top management is a prerequisite to satisfactory release of men for training.

'Don Servo's' second point is very important. The provision of a really adequate demonstration laboratory will cost much money and this is why the educational effort should be focused in one centre. The EIA has approached the National Union of Manufacturuers Advisory Service, the Electronic Engineering Association and the Scientific Instrument Manufacturers' Association with a view to holding joint talks.

Your correspondent's last point would appear to be more a matter for the DSIR. The electronics industry and some user firms are already spending a great deal on research and development in control, but the standard pattern for joint research would be a control research association under the DSIR, with Government and industry contributing financially. The idea of establishing a Control Research Association on the same site as a Control School is intriguing.

Chairman, Scientific Advisory Committee,
Engineering Industries' Association DAVID FOSTER

CONTROL
VOLUME 2 NUMBER 13

Second year course

Naturally we are not proud of this emaciated issue of CONTROL, whose size and appearance fall so short of what we normally provide. We apologize to readers for it, but as they doubtless realize the causes are beyond our influence. Indeed we are lucky to be able to produce any kind of issue; many magazines will not be seen again until the printing dispute is over, and some may not be seen again at all. As it happens, this shadow of the real thing is our first birthday issue, and the end of our first year prompts us to briefly look backwards and forwards.

The response to CONTROL during its first year has exceeded the most extravagant hopes of those who planned it. Undoubtedly there existed a year ago a real need for a British journal dealing with the youthful technology of control engineering in an authoritative yet readable and lively way. CONTROL has quickly established itself as doing this. Of course there have been mistakes – and we are grateful to readers for pointing out some of them. Of course there is much room for improvement. Yet over the last year letters of critcism have been conspicuous for their rarity. Without being at all complacent we believe CONTROL has made a good start.

In general we have aimed our text at the engineer in the field, for CONTROL is primarily the technical magazine for the professional control engineer or control technician – it provides him with technical information, news of events, people, equipment and literature, ideas, a forum for discussion, and advertisements relevant to his work. But, as we wrote in the first issue, CONTROL aims also at the users: consulting engineers, development engineers, plant engineers, production engineers. Here the magazine is deployed on a far wider technical front; we plan to make it a spearhead in the important struggle to make engineers more control-minded, giving more educative and application articles.

Thus CONTROL will be an even meatier magazine in its second year. Moreover the coming twelve months will be significant for control engineering, with the first international congress on automatic control, as well as important events at home such as the IEA show. We believe also that it will see the establishment in this country of some national centre for control engineering development and education. When free of present production doldrums, CONTROL will set its course to catch this strengthening wind of automatic control.

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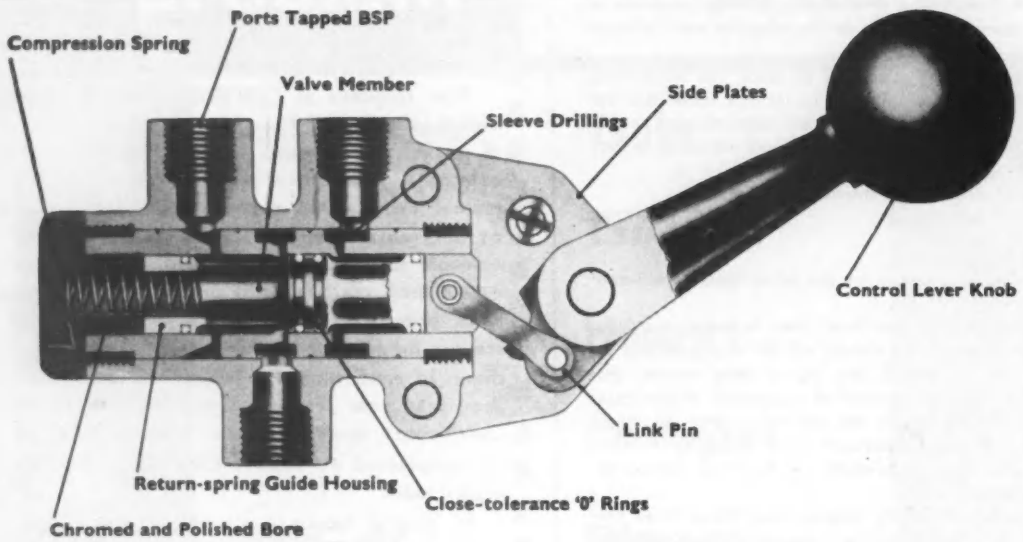

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INDUSTRY'S VIEWPOINT

A monthly article by a prominent man in the control industry on a subject chosen by himself

Pneumatics need not worry while electronics is an offshoot of radio says David B. Pinkney, Managing Director of Taylor Controls in calling for . . .

THE GENTLE SWITCH

Closing an air valve stops the activity of the compressed air gently, progressively and without violent reaction. On the other hand, when an electric current is cut off by a switch it protests fiercely, with all the momentum of inductances in the circuit and the full force of the power station behind it. Therein lies a fundamental difference between pneumatics and electrics or electronics.

It is fascinating to watch the fluctuating battle in the process control field between pneumatics and electronics. It is the perpetual battle of middle-aged experience against youth. The outcome is inevitable: new discoveries and new techniques will one day give equality to electronics, but then some fresh discovery will come along and start a fresh battle. In the midst of battle, it may be wise to stop and look at the real fundamentals unclouded by short-term arguments.

Process control by its very nature deals in liquids, gases and solids, in their heating, cooling, distilling and reacting. These processes, having time scales of the order of minutes, are relatively slow. The major progress in electronics has been in the fields of radio and nuclear physics against a background of milliseconds. Direct current systems lend themselves best to the slow speeds of continuous processes, so let us look at the gaps in the armoury of d.c. electronics.

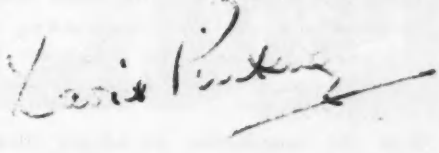
Reference levels for voltage are often required. The need is for something as simple and flexible as the common air reducing valve.

Most measurements in process control are mechanical ones like flow, pressure and level; even temperature is a measure of the mechanical motion of molecules. The conversion of stepless mechanical motion into pneumatic pressure is easy, but the conversion to a d.c. electrical signal is still relatively difficult. Slide wires have friction, differential transformers require an electrical conversion to d.c. and strain gauges are not stable enough. Some new discovery or technique is required and a gentle electric switch would be a great step forward.

The ordinary pneumatic three-term controller or, to give it a more high sounding name, the second order linear differential equation computor, is essentially a d.c. instrument which can easily handle very long integral times. Its electronic counterpart has two great needs: a really stable, simple and easy to manufacture d.c. amplifier, and a capacity circuit that can readily handle integral times in excess of 30 minutes. Again, new discoveries and techniques are required.

The air cylinder or the pneumatic diaphragm motor can produce considerable force with zero power consumption at either end of their travel. In like conditions the electric motor goes up in blue smoke; the solenoid is liable to produce smoke at all times, if much force is required. This is the last major item missing in the electronic set-up.

The conclusion is a simple one. As long as electronics for process control remains an offshoot of the great radio and communications industry, it will not replace pneumatics. When it puts its house in order, stands on its own feet and gives the world some discoveries of its own then, and only then, will pneumatics really need to be worried. Plant designers and instrument engineers should realise that for the present each has both good points and limitations.



Autocontrolled Oxygen-Steel Production

by J. BELLIS, *Instrumentation Engineer, Evershed & Vignoles Ltd.*

The technique of steel-making in a converter was first developed by Henry Bessemer just over one hundred years ago. The Bessemer converter made possible the economic production of steel on a large scale and was a major contribution to the Industrial Revolution in this country. The original converter was modified by Thomas to its present-day form by the introduction of a basic dolomite lining which allowed the use of the high phosphorus ores found in this country.

Steel made in a converter suffers from the limitation that large quantities of air are used in the conversion of the pig iron to steel. This air contains 79% of nitrogen some of which will be retained in a combined state in the steel with resultant brittleness. Steel made in this manner is not eminently suitable for rolling to thin-gauge sheet nor for deep-drawing requirements.

A large proportion of the steel made on the Continent is Thomas steel and much research work has been carried out to make the steel produced in a converter suitable for extra deep-drawing. The processes tried have been the enrichment of air by oxygen, the use of oxygen/carbon dioxide and the use of oxygen/steam.

With the introduction of oxygen blowing, the quality of steel has been improved, and in many cases been made equal to that produced from an open hearth furnace. The rate of steel production in a converter is higher than for any other process, and 25 tons can be produced in a blowing time of 7-15 min, compared with 200 tons in a period of 10 hours in a large open hearth furnace.

Air/oxygen and steam/oxygen blowing have now been adopted for the converters at Richard Thomas & Baldwins' Ebbw Vale Plant, and their four converters are now in successful production using these techniques in addition to the conventional air blowing.

The Thomas converter.

The converter is a pear-shaped vessel, open at the top, mounted on trunnions and provided with a wind-box at its base. The blast enters the vessel through the trunnions, passing into the wind-box. From the wind-box it passes upward through small holes in the bottom lining of the vessel.

The converter can be swung on its trunnions through 310°, the driving force being a hydraulic ram working a rack and pinion. The operator tilts the vessel by means of a lever-operated positioning valve.

The vessel is charged in the horizontal position through the opening at the top, the charge being

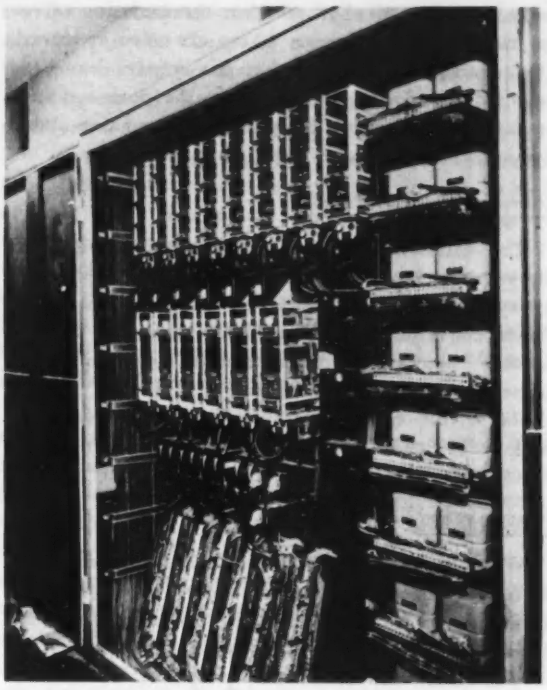


Fig. 1 Much equipment is installed in the cleaner atmosphere of the control room. These three-term controllers are mounted behind the main instrument panel.

25 tons of molten pig iron with lime as the fluxing agent. When the vessel is horizontal, the charge lies in the bulge at the waist of the vessel and is thus clear of the holes in the bottom. The blast is then brought on and raised to operating pressure, and the vessel is raised to the vertical, the force of the blast being sufficient to form a cushion so that the molten metal is held clear of the bottom.

The process of converting molten pig iron to steel is an exothermic one, no fuel being used. The oxygen in the blast burns the carbon and other impurities, generating sufficient heat to raise the temperature of the metal to that required for pouring. The carbon monoxide produced burns at the mouth of the converter and the end point of oxidation is observed by the operator when various colour changes occur in the flame. Phosphorus, together with a certain amount of sulphur, is absorbed in the lime which is poured off prior to the molten steel being poured into a ladle for teeming.

Since only a limited amount of the sulphur can be taken into the slag, most of it is removed from the pig iron before it is charged into the vessel. This is done by the addition of sodium carbonate which reduces the sulphur in the pig iron through forming a slag of sodium sulphide.

Autcontrol and instrumentation.

The quality of the steel produced in the converter depends to a large extent on the accuracy of measurement and control. The pressure of, and the amount of oxygen within the blast, together determine the rate at which oxidation takes place. The more closely these two variables are controlled, the more certain is uniform removal of impurities throughout the steel, and the more economic the consumption of oxygen. In addition, to ensure a consistently high quality of steel from every charge of the converter, a high degree of accuracy is required in metering.

In order to facilitate the switching of control from one converter to another, an electrical system of transmission and control is used. To meet the arduous conditions prevailing on site owing to the ejection of particles of slag from the converter, and the presence of lime dust, as much equipment as possible is mounted in the control room where cleaner and less arduous conditions prevail. To achieve this, the Evershed three-term controllers and power supply units for the various Evershed electronic repeater transmitters are rack-mounting models. These units are installed in the cabinet (see Fig 1) located behind the main instrument panel. A further cabinet (Fig 2) houses the relay units and associated equipment performing various switching functions.

The lay-out of the instrumentation scheme was designed so that the information and control facilities required by the technicians are presented on the main panel in the central control room; instruments and controls essential to the operator are provided on four control desks, one for each of the converters. In addition, a small panel on the converter platform

Fig. 2 Relay units and associated equipment.

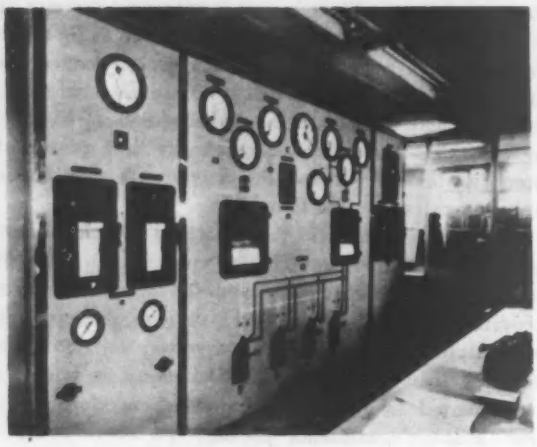


Fig. 3 The central instrument panel in the control room indicates to the supervisory staff the converter and type of blow in use.

allows the converter foreman to select the vessel to be blown.

The control room

The central panel (Fig. 3) has a middle section in the form of a simple graphic, which enables the technician to see which converter is in use and the type of blow in progress. Indication is provided on this centre section for the blast pressure and air, oxygen and steam flows. A record is made of the air and oxygen flows and the air/oxygen ratio on a Triplex recorder, with a similar recorder keeping a record of steam and oxygen flows and steam/oxygen ratio. The two ratios are expressed in terms of percentage oxygen in the total blast, and all flows are true mass flows, i.e. they are corrected for pressure and temperature variations. In addition, the controller settings for the ratio control are provided on the instrument panel, and arrangements are made for pre-setting and indication of the total summated oxygen. The outer sections of the central instrument panel accommodate direct reading instruments to record pressure drops and temperatures of oxygen and steam at the oxygen pre-heater and at other points on the supply side. Mounted internally in the instrument cubicle is a high pressure oil supply circuit with solenoid operated valves for the automatic operation of the isolating valves on the hot and cold oxygen and steam mains for each converter.

The operator's desk.

Indication and operating facilities for controlling the blow are provided on the converter operator's desk (Fig. 4). Here, blast pressure, air/oxygen and steam/oxygen ratios are displayed. The desired value and hand control settings for blast pressure control, are also located on the desk. The type of blow, i.e. air, oxygen or steam/oxygen, is selected by the operator by means of the selector switch and initiating push button on the desk. Indication is provided for valve position to show whether the isolating valves on the oxygen and steam mains are open or closed. The operator is warned that his vessel has been selected for blowing by a lamp on the desk and once he has commenced his blow, his desk remains operative until he pushes the 'clear' push button.

Converter Selector Panel.

The foreman selects a converter for blowing with the aid of the converter selector panel on the platform. A system of signal lamps on this panel indicates which converter is in use, and, when the blow is finished, shows that the system is clear and that a further vessel can be selected.

On all the control panels and operators' desks, a 'lamp test' push button is provided by which the signal lamps can be tested for bulb failure.

Steam/oxygen blowing.

When the vessel is charged, and is lying horizontally, the operator turns his blow selector switch to steam/oxygen, and presses his initiating push button. The isolating valves on his steam and hot oxygen mains are automatically opened and this is indicated on the valve position indicator on his desk. The required blast pressure (normally 25-30 lb/in^2) is then set on his desired value setting control. The pressure may be brought up either automatically or on hand control, the controller then being switched to the automatic mode of operation. The pressure and ratio are maintained constant by the action of the three-term controllers. (The desired value ratio, usually 45-48% oxygen, is set on the central control panel by the technician in the control room).

When the pressure reaches a safe value, the operator tilts his vessel to the upright position and

Fig. 4 Each converter is controlled from a separate desk.

the blow continues until the impurities are removed and the pig iron charge is converted to steel. When the operator decides that this point has been reached, the converter is lowered and a temperature dip is taken and any further fluxing limestone is added. The vessel is then usually taken up for a further short blow, this second blow normally being on air/oxygen, since this tends to remove from the steel any free hydrogen which has dissociated from the steam. The vessel is then lowered, the slag poured off, and the molten steel poured into ladles for teeming by inverting the converter. The operator then turns his blow selector switch to 'off', pushes his button, and the isolating valves close.

Fig. 5 shows the circuit of the metering, computing and control equipment for steam/oxygen control. The system adopted causes the pressure control to operate on both steam and oxygen control valves in tandem, whilst the ratio control operates on both valves in opposition as a trimming control. Under this mode of control any adjustments of the ratio do not upset the pressure in the system and, as the control valves are sized to give approximately the desired ratio on pressure control alone, a very stable and rapid control can be established. This is important because the total length of the blow may be as short as nine minutes, and any oxygen and steam blowing before a safe pressure for raising the vessel is reached represents a financial loss. It has been found that with this mode of control the pressure can be stabilized at the desired value within approximately 20 seconds from the start of blowing and the ratio can be stabilized in a further 20 seconds and can be held stable to within a 0.25% of the ratio.

Air/oxygen blowing.

For this the operator selects his blow and operates his setting controls in the manner already outlined. The cold oxygen isolating valve is automatically opened—no isolation is provided in the air main. The method of control is similar to that for steam/oxygen, but for air/oxygen blowing the pressure controller adjusts both the air blast valve and the oxygen valve in tandem, and the ratio controller trims on the oxygen valve.

The operating procedure for air blowing is much the same, the pressure controller adjusting the air blast valve to maintain the blast pressure constant.

End point determination.

In general, in the past, the termination of the blow has been determined by the operator from the appearance of the fumes given off when the phosphorus present is taken into the slag. Experiments based on temperature of flame and density of fume etc. have been carried out in this country and on the continent to establish a better method of determining the end point of the blow. A different method has been

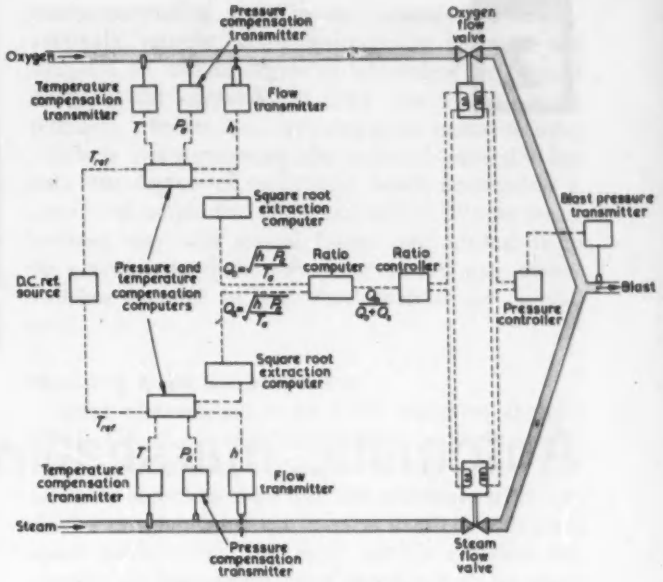


Fig. 5 Metering, computing and control circuit for steam oxygen blowing. Q_o and Q_s are corrected oxygen and steam flows respectively. T_s (absolute temperature) = T_{ref} + T.

incorporated in the Ebbw Vale scheme, whereby the total oxygen used in a blow is integrated and indicated. It is assumed that provided the quality of pig iron and lime used is reasonably consistent, the oxygen used per blow should be substantially constant. An alarm contact is provided on the integrator which lights a lamp on the operator's desk when a pre-set amount of oxygen has been blown. The setting and re-set controls for this are provided on the main control panel for operation by the technician. In steam/oxygen blowing, the oxygen integrated includes that which dissociates in the converter from the steam, in addition to the tonnage oxygen. Similarly, for air/oxygen blowing, the oxygen present in air is added to the tonnage oxygen.

Safety features.

Since the loss of blast pressure during a blow allows the molten metal to fall to the bottom of the vessel, it is essential that the system fails safe with the valves prevented from closing in the event of a power supply or circuit failure. The valve positioners used throughout the scheme are electro-hydraulic and incorporate a hydraulic locking valve in the hydraulic circuit operating the isolating valves.

In addition to the protection against circuit or mains failure, the relay circuits are interlocked to prevent the accidental selection of more than one vessel at a time and also guard against withdrawal of control from an operator's desk during a blow.

The electronic instrumentation and control equipment is arranged to facilitate maintenance and service operations without interference with the day-to-day operation of the plant.

PART 2

Automatic marshalling of railway wagons

by **J. F. H. TYLER**

Signal Engineer, Southern Region, British Railways; formerly Assistant Signal Engineering Officer, British Railways Division of the British Transport Commission

The control and operation of the retarders

Let W = Total weight of the wagon, lb.
v_2 = Wagon exit speed from retarder, ft/sec.
x = Distance to run to next wagon in marshalling siding, ft.
a = Rate of deceleration, ft/sec².
G = Equivalent gradient from retarder to a point x ft distant in the marshalling siding.
μ = Coefficient of rolling resistance.
g = Gravitational acceleration, 32·2 ft/sec².
Then

Then $$\frac{W}{G} - \mu W = \frac{W}{g} a$$

or

or $$a = g \left(\frac{1}{G} - \mu \right)$$

But

$$v_2^2 = 2ax$$

Therefore

$$v_2 = \sqrt{\left[64{\cdot}4 \left(\frac{1}{G} - \mu \right) x \right]} \qquad (6)$$

Knowing x and μ, one can calculate v_2 since the geometrical relationship between G and x are known. It is interesting to note that neither the weight of the wagon nor the entry speed is required to make the calculation.

Wagons proceed over the hump in random order so far as running characteristics are concerned. A good running wagon may follow a bad running wagon or vice versa, and it is most important that adequate separation should be maintained between the cuts of wagons as they proceed through the switching zone. If the degree of retardation applied at the primary retarder took into account the distance the wagon has to run, a bad running wagon with a long distance to run might overtake a good running wagon with a short distance to run. It is not sufficient to prevent overtaking. Consecutive cuts must gravitate with at least one clear rail circuit between them, because unless this is so, the apparatus is unable to distinguish between them and both cuts will be routed to the destination of the leading cut.

The primary retarders

The function of a primary retarder is therefore to ensure separation and the degree of retardation applied is such that the exit speed is related only to the rollability of the cut. Thus G and x in equation 6 must be regarded as constants so chosen that the bad running wagon passes through the primary retarder unbraked.

Although, fundamentally, it is unnecessary to measure the weight of the wagon, a light wagon might be derailed if the retarder pressure were too great, and in fact a measurement is made which classifies the wagon as light, medium or heavy and the pressure adjusted accordingly. Prior to the entry of the wagon, the retarder is preset at this pressure and released when the speed has been reduced to that corresponding to the wagon rollability.

The secondary retarders

The function of secondary retarder is to apply such braking as will bring the wagon into contact with the wagon next ahead in the marshalling siding at not

greater than the safe buffing speed of 4 miles/h, a speed which ensures that the contents of the wagon will not be damaged provided they are reasonably well packed.

So far as the secondary retarder is concerned, therefore, the exit speed is in accordance with equation 6. The retarder pressure is preset as before according to the weight category of the wagon, but in addition to measuring the rollability, an estimate of the distance to run is necessary before the exit speed can be calculated.

If the secondary retarders are manually operated, estimates of rollability and distance to run can be based only on experience, although the retarder operator may be assisted by a control knob on the panel calibrated in terms of exit speed. This latter arrangement involves the installation of speed measurement and automatic release of the retarder when the speed has dropped to the preset value.

If the secondary retarders are fully automatic in operation, the solution of equation 6 is achieved by associating a small analogue computer with each secondary retarder. Into this computer is fed information regarding the rollability, for which a further measurement is usually made on the curved track between the primary and secondary retarders, and the distance to run. As before, the secondary retarder is released when the speed has dropped to the calculated figure.

A block diagram of the method of controlling the retarders in a fully automatic yard is given in Fig. 11.

Measuring wagon weight

If weight-automatic retarders are used, weight measuring devices are not necessary, but this type of retarder has not been used so far for automatic operation in Britain although they are giving good service in non-automatic yards. Excellent though they are in operation, weight-automatic retarders require heavy concrete foundations and their construction is such that track circuits cannot be used within the retarder length. The non-weight-automatic retarder, which is lighter and may be mounted on timbers, has been selected for all recent marshalling yards in this country. The weight-automatic retarder, being hydraulically operated, has available an infinite degree of adjustment (in manual operation the operator can 'feel' the wagon on the retarder) whereas the non-weight-automatic retarder which is electropneumatically operated generally has only four degrees of retardation, which nevertheless is considered ample for automatic control. Weight measurement may take several forms: one method is to cut a narrow slot in the web of the rail and insert microswitches operated by the wheel pressure on the rail head.

Measuring speed and acceleration

Speed measurement is by radar using the Doppler effect. This is not quite so simple as it might appear because the reflecting surface of the wagon varies considerably according to its type, and secondary reflexions, due to swinging couplings, tend to interfere with exact speed measurement. The most suitable radiation frequency has been found from experience to be about 10,000 Mc/s (i.e. a wavelength of about 3 cm).

The signal is radiated from a parabolic metal reflector aerial placed between the rails, and the return signal is picked up by the same aerial unit. A sample of the transmitted signal is mixed with the incoming signal from which a difference (or Doppler) frequency is obtained which is proportional to the speed of the wagon. It can be shown that the speed of the wagon is

$$v = (f_1 - f_0)\frac{\lambda_0}{2}$$

where f_1 = frequency of the incoming or reflected signal, f_0 = frequency of the transmitted signal, and λ_0 = wavelength of transmitted signal.

The speed measurement is brought into operation by the occupation of an appropriate rail circuit approaching the retarder. It will be appreciated that, in this application, the radar must only operate at short range to avoid confusion with wagons due to be switched to an adjacent track.

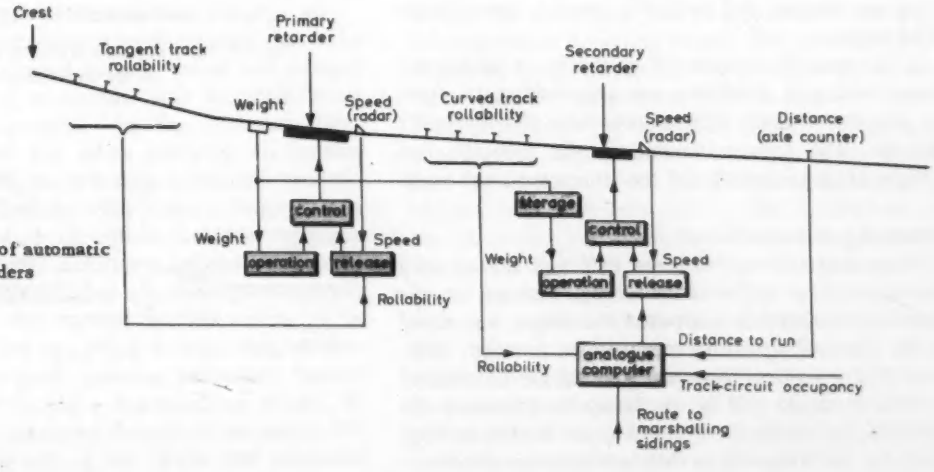


Fig. 11 Block diagram of automatic control of retarders

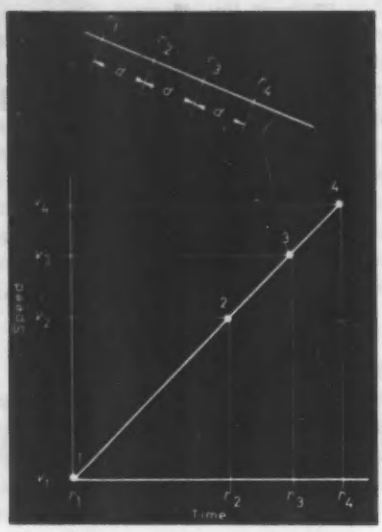


Fig. 12 Graph illustrating how rollability is measured

Rollability

Now it has been shown that rollability is related to acceleration (or deceleration). To measure the latter, it is necessary to take at least two measurements of speed, and to determine whether or not it is varying at least three measurements are necessary. Fig. 12 explains a fundamental method of determining rollability. Four timing devices (in the form of a treadle-operated contact or a photelectric cell) are located equal distances apart.

From point 1 to point 2, the average speed $v_A = \frac{d}{t_A}$

From point 2 to point 3, the average speed $v_B = \frac{d}{t_B}$

The average acceleration $= \frac{2(v_B - v_A)}{t_A + t_B}$

$$= \frac{2d(t_A - t_B)}{t_A t_B(t_A + t_B)}$$

where $t_A = t_2 - t_1$, $t_B = t_3 - t_2$ and d = distance between timing points.

If rollability is considered to remain constant, no more than three timing points (or two speed measurements) are necessary but for greater accuracy a fourth point may be provided to enable a further measurement to be taken.

It is generally considered necessary to make two measurements of rollability, one approaching the primary retarder and the other approaching the secondary retarder. The former determines the rollability on straight or tangent track and the latter on curved track.

Calculating distance to run

Siding occupancy or distance to run is not an easy measurement to make economically, because, at the time the measurement is required, the wagon next ahead in the marshalling siding may still be moving. Thus, even if the state of occupancy could be determined exactly, it would still be necessary to determine the speed of the wagon next ahead (were it still moving) to enable the computer to calculate its point of rest.

For these reasons, distance to run is calculated on the assumption that each wagon is correctly retarded. On this assumption, one need only count the wagons into each marshalling siding and feed the information into the appropriate computer when required. In view of the operator's overriding control (see next section) of the retarders, this solution is working well in practice. Axle counters, consisting of a wheel-operated treadle and relay counting apparatus, are therefore provided at the entry to each marshalling siding and the information fed into the appropriate retarder computer when a wagon intended for a particular siding is about to be braked by the retarder. In the event of a bad running wagon coming to rest short of its target—and a really bad runner will sometimes scarcely clear the switching zone even though unretarded—the operator from his commanding position in the control tower is able to operate the retarder manually to avoid the heavy collision which would otherwise occur. He is also able to direct wagons to another siding by manual control of the points if that is necessary. In some yards, counting is done manually by the operator depressing a button corresponding to the number of wagons in a cut.

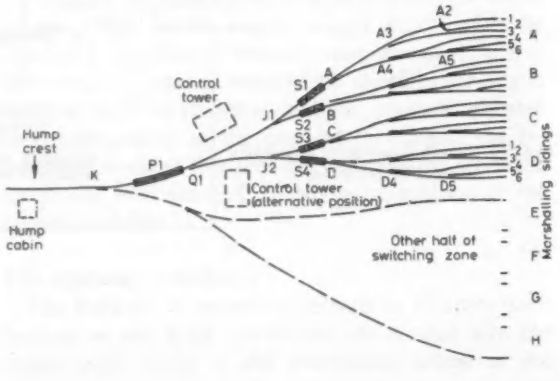
The marshalling sidings at some yards are also divided into sections by track-circuits. Four equal sections are usual. In the event of a wagon coming to rest short of its target and remaining on a track-circuit which would otherwise have cleared, the computer makes an allowance for the shorter length available when the next train is marshalled.

Overriding control

In an emergency the operator must be able to override automatic braking (if provided) at the secondary retarder and because, as a result, a wagon may inadvertently be stopped, overriding control is necessary at the primary retarder.

Owing to the variation in rollability and the difficulty or assessing the actual point of rest in the marshalling siding, there has been reluctance to accept automatic operation of secondary retarders, but experience indicates that automatic operation has an advantage in that the operator can concentrate on watching for the bad

Fig. 13 Diagrammatic layout of points and retarders in the switching zone



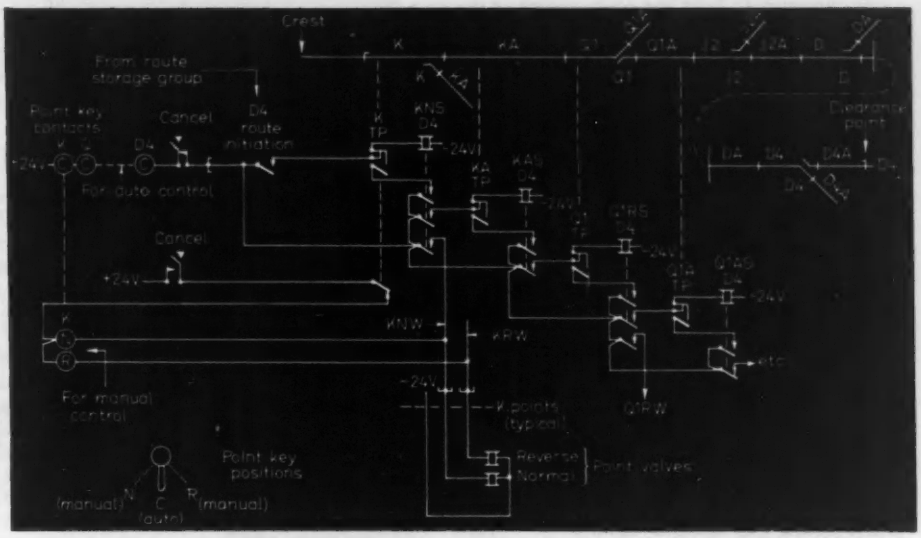


Fig. 14 **A section of a typical progression realy group showing point operation**

running wagons. For the good running wagons, automatic operation always gives more consistent operation than manual operation.

There is at present no fully automatic marshalling yard in this country, but all yards under construction will be of that type.

Control of points

If, as stated earlier, wagons are pushed over the hump at a speed of 3 ft/sec, single wagons of equal rollability will follow each other at intervals of 7 sec, but if a good running wagon follows a bad running wagon or the leading cut has to be retarded more than that which follows, the time interval may be very much less.

Fig. 13 shows, in diagrammatic form, the arrangement of the points in the switching zone and Fig. 14 shows in detail a typical route from the crest of the hump to one marshalling siding. Preferably the switching zone should be as short as practicable and the relative position of the points is therefore fixed by curvature of the switch rails, the number of marshalling sidings and the length of the retarders.

The whole switching zone is track-circuited. Normally de-energized track-circuits (usually called *rail circuits*) are used because it is essential that the track-circuit should indicate 'occupied' in the minimum time. (Track-circuits used for safety purposes on running lines are always of the normally energized type and when the train shunts the relay it has a longer release time than in a rail circuit, where the train completes the circuit and the relap picks up to indicate 'occupied.')

Points in the switching zone are electropneumatically operated because this method enables points to be operated in about 0·6 sec, which is faster than all-electric operation. The point operating mechanism consists of an air cylinder having a double-acting piston, the rod from which is connected directly to the points. Air is admitted to one side of the piston and exhausted from the other by the action of electropneumatic valves. The air pressure is 60 lb/in.^{2}.

To operate the points, it is necessary to energize the appropriate electroneumatic valve and de-energize the other. Detection contacts connected to the points serve to indicate electrically the position of the points in the control tower.

Now as the wagons are pushed over the hump, they may either be directed to their destined marshalling siding as a result of electrical storage of the cut list, or, as each cut reaches the crest of the hump, the hump signalman will note the chalk marks on the leading end of the leading wagon in the cut and depress a push-button corresponding with the destined marshalling siding. The actual method in use depends on the overall method of control of the working of the yard but, in each case, as the cut passes over the crest of the hump, a relay contact closes the appropriate point operating circuit.

Operation of the rail circuits

Fig. 14 shows a typical route into the marshalling sidings, the points and rail circuits involved and a typical progression operating circuit. The quickest possible release of points is essential and points must be free to throw until the last possible moment. Each set of points must therefore be provided with a short controlling rail circuit which starts no closer to the toe of the switches than the distance moved by a wagon travelling at the highest speed for a time equal to that required to operate the points. For example, if the points take 0·6 sec to operate and the maximum possible speed of the wagon at that point is 30 ft/sec, the rail circuit must start at a point not closer than 18 ft from the switches. The rail circuit must not be shorter than the longest 'inside' wheelbase, or it would indicate 'clear' between the wheels and the storage equipment would treat each pair of wheels as a separate cut. Between each point controlling rail circuit, another rail circuit

is provided to hold the route ahead of the wagon.

One can see from Fig. 11 that two cuts for a particular marshalling siding may possibly be in the switching zone at the same time. In addition, each rail circuit, except the last, will be operated by cuts destined for other marshalling sidings. The point-operating circuit for the route to a particular marshalling siding must take these conditions into account.

Assuming the initiating contact to be closed for a cut to be routed to Siding D4, if all rail circuits are clear i.e. no other cut is occupying any part of the route to siding D4, relays KNSD4, KASD4, QIRSD4, QIASD4 . . . D4RS and D4AS will operate. If say, rail circuit D is occupied, relays beyond that point will not be operated by the closing of the initiating contact as mentioned although they might have been operated by it on a previous occasion. The operation of relays KNSD4, QIRSD4, etc., cause the respective points to be operated to the required position (if they are not already lying in that position).

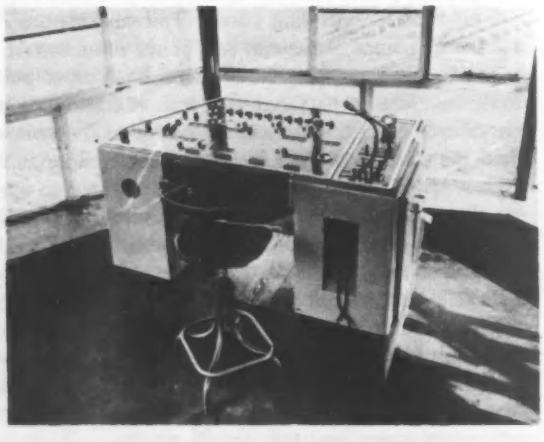
The cut now proceeds over the hump and occupies rail circuit K, which causes rail circuit repeat relay KTP to pick up and lock relay KNSD4. It also disconnects the whole circuit from the initiating contact until rail circuit K is again clear. As the cut gravitates through the switching zone, each rail circuit is occupied in turn and the relevant portion of the operating circuit is isolated from the influence of the following cut.

In the event of a good running wagon overtaking a bad running wagon, the two cuts will be routed to the destination of the first. Individual point switches enable the signalman to override the automatic point operation at any time.

Control of marshalling operations

There are two methods by which the complete marshalling operation may be controlled. One is to divide the work between a signalman located at the hump who is responsible for setting the route and retarder operators who are located in a 'tower' overlooking the switching zone. The other is to combine the functions of signalman and retarder operator.

Fig. 15 One of the two control panels in the tower at Temple Mills yard



In the first, the signalman at the hump notes the number of the marshalling siding chalked on the leading wagon of the cut and depresses a corresponding push-button on his control panel. This action electrically stores that route to follow the preceding cut. It is usual to arrange for up to three routes to be stored in this manner. The destination of the cut is also transmitted to the appropriate retarder operator and exhibited on his panel to enable him to judge the degree of secondary retardation necessary (assuming the primary retarders to be automatically operated) and either to retard the wagons as required if the secondary retarders are manually operated or make a correction if they are automatically operated.

In the second method, the cut list is transmitted, generally by teleprinter, direct to the control tower, where the signalman depresses, in cut order, pushbuttons corresponding to the marshalling siding numbers (Fig. 15). This stores the routing of the cut electrically so that there is nothing further to do in connexion with point setting. This leaves the signalman free to supervize the retarder operation. In this method, only one man is required, whereas if routes are set from the hump, at least two and possibly three men must be on duty at the same time.

In view of the limited experience with automatic marshalling yards, it has not yet been possible to decide which method is the better in practice, although, theoretically, the second method seems to have technical and economic advantages.

Of the two recently installed marshalling yards on British Railways, Temple Mills (Eastern Region) has the separate arrangement but Thornton (Scottish Region) has the combined arrangement. New yards under construction at Margam (Western Region) and Perth (Scottish Region) will also be controlled completely from the tower.

Conclusion

Whilst the design of a modern automatic marshalling yard may be exact, it is based on a number of assumptions concerning the rollability of British wagons and the best operation in practice is given by that system which reduces the margin of error to a minimum. Since nationalization, although steps had been taken before, the grease-lubricated axle box, which resulted in notoriously bad running wagons, has been eliminated.

In its outlook on marshalling yards, their location and automatization, British Railways are showing enterprise in their introduction of modern scientific devices to solve a complex railway transport problem.

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3. Sadler, R. E.: 'The Design and Equipment of Modern Marshalling Yards,' *Proc. Instn. Civil Engnrs.*, 1953, *11* (October) Part II, p. 745.

New for Control

A monthly review of system components and instruments

TRIP AMPLIFIER

for use with thermocouples

A fully-transistorized thermocouple trip amplifier (type N642) has been introduced by Ekco Electronics Ltd. It monitors the temperature at a specific point within a plant and trips external guard circuits by releasing an internal relay when the temperature reaches the preset trip level. This level is set by means of a 10-turn helical potentiometer with a dial directly calibrated in temperature. A low-margin warning releases a second internal relay and can be set at any point within the meter range, while the meter range can be supplied to order covering up to 100% of the ambient-to-trip-level range, with linear calibration.

Normally operated in conjunction with a chromel-alumel thermocouple the amplifier can be used with other types with a slight modification. It covers the range zero to 250°C and is fully fail-safe with an indefinite life expectancy. A trip will also occur with an open-circuit thermocouple. The range of the instrument can be extended up to 1000°C to special order.

The amplifier requires an a.c. mains supply of 110–120 V or 200–250 V, 45–60 c/s. Four instruments can be installed side by side in a frame which fits a standard 19 in. rack.

A transistor chopper is incorporated in the input circuit, operating at approximately 700 c/s so that 50 c/s pick-up is rejected. This is followed by an amplifier and a detector which in turn releases the warning and trip circuits.

Tick **No 171** on reply card

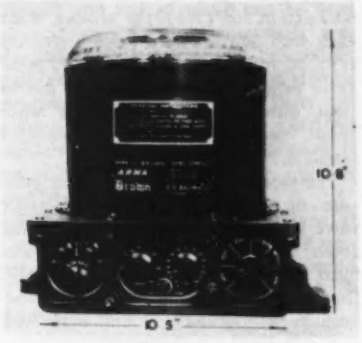
GYRO COMPASS

a claim to be the most advanced

S. G. Brown are now producing what they claim to be is the most advanced North-seeking gyroscopic compass in the world. This Arma Brown gyro can be used either as a North-seeking compass or as a directional gyro.

The complete self contained unit measures approximately $10\frac{1}{2} \times 10\frac{1}{2} \times 10\frac{1}{2}$ in. and weighs about 30 lb. The necessary motor generator set is supplied separately. It will perform all the functions required of a gyro compass, supplying information to operate all types of repeaters, automatic helmsmen, and inputs to D/F and radar.

A feature of the gyro, using two degrees of freedom, is in the suspension. The gyro is encased in a hermetically-sealed spherical housing, which, is completely immersed in a sealed tank containing a high density fluid. Frictionless suspension is achieved by suspending the gyro in the fluid at neutral buoyancy and keeping it centred in the tank by ligaments. Ideally the centre of gravity is made coincident with the centre of buoyancy and this is achieved in the Arma Brown Gyro to within a few millionths of an inch.



A compact gyro-compass

Twisting the ligaments creates precession in both azimuth and tilt and makes the gyro North-seeking. This is achieved by the use of electrical pick-offs and transistorized amplifiers. Synchronous outputs are provided as a basis for repeater and automatic steering operations.

Tick **No 172** on reply card

DIGITAL VOLTMETERS

employing in-line display

A new range of digital voltmeters is being introduced by Solartron. The voltmeters have in-line display of digits, using back projection illumination. The display may be located remotely, or two displays may be operated from one unit. The absolute accuracy of the two instruments is better than 0·1% short term, or 0·25% long term. Outputs of decimal coded information are provided for data processing.

The LM 901 will measure up to 99·9 V positive or negative d.c. in three ranges. An 'add 10' facility extends this full-scale reading to 109·9 V. Under normal operating conditions the LM 901 continuously monitors the applied voltage, but a model is provided which allows a front panel push-button or external relay contacts to give controlled lock-out. This can be used sampling the instantaneous value of rapidly varying signals which, in the LM 901, will normally give a recycling display.

The LM 902 is a four-window digital voltmeter of 0·1% accuracy and having five full-scale ranges from 0·1599 V to 1599 V. It incorporates those facilities described for the three-window LM 901; in addition there is a variable dead-zone control for stabilizing the reading on fluctuating inputs and up to 40 dB common mode rejection of 50 c/s at the input.

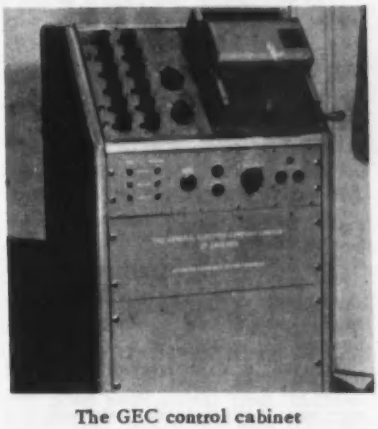
Tick **No 173** on reply card

JIG BORING MACHINE

with automatic positioning

The Spacematic 2436 is a new version of the Newall 2436 jig boring machine. It differs from its predecessor in having an automatic positioning system, which has an overall accuracy of 0·0005 in. In addition it has a patented roller measuring system which enables table settings to 0·0001 in. to be made.

The machine can, by using these two systems, fufil two roles. It can cater for the highest accuracy jigs and components by employing the manual setting system.



The GEC control cabinet

The automatic system is used for those components where a lower accuracy can be tolerated.

The table surface is 24 × 36 in., the longitudinal and cross traverses of the table being 24 and 18 in. respectively. The rapid (electric) traverse rate of cross slide and table is 90 in/min, and of the quill head on the column 50 in./min. The table milling feeds are continuously variable from 0·06 to 12 in /min.

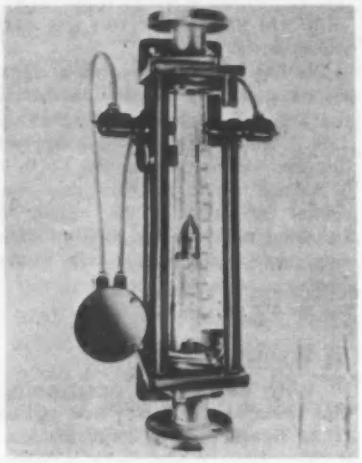
The automatic measuring and control system was designed by the General Electric Co. Ltd.

Tick **No 174** on reply card

FLOW ALARM

for use with rotameters

An alarm for fitting to their type 907 and 914 industrial rotameters has been introduced by the Rotameter Manufac-



The alarm fitted to a rotameter

turing Co. Ltd. It comprises a light source and a photoconductive cell which are clamped to opposite pillars of the rotameter frame. The alarm is actuated when the float cuts the beam between the source and cell.

The unit can be used to give an alarm on minimum or maximum flows, the values of which are set by moving the source and cell up or down the frame. Automatic or manual reset is optional.

The relay and power supply unit are housed in a steel case which measures 7½ × 4½ × 5 in.

Tick No 175 on reply card

LEVEL INDICATOR

fully transistorized

A level measuring unit from GEC measures the quantity of liquid or free-flowing granular material in a container.

The unit is capacitance-operated and works off a 24 ± 4 V d.c. supply. The maximum distance between the unit and the detector head is 15 ft. The equipment is fully transistorized and employs printed circuits.

The quantity of liquid in the container is displayed on a meter to an accuracy of ± 2 ½% over the temperature range of 0–35°C. An accuracy of ± 5% is obtained over the complete working temperature −40 to +70°C. A relative humidity of 100% is permissible.

Tick No 176 on reply card

BOOSTER RELAY

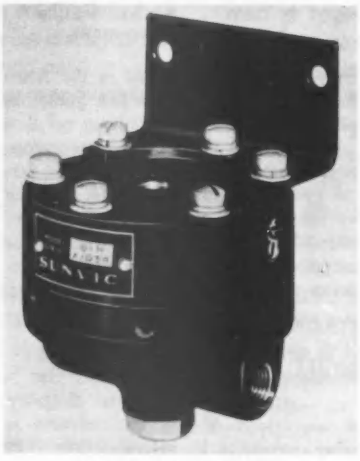
for high-speed valve operation

A booster relay has been introduced which, it is stated, will improve design of process control loops by making it possible to increase valve stroking speeds considerably without loss of stability.

Sunvic state that using the new 61H relay in conjunction with their high precision valve positioner applied to a 1 in. stroke valve with a 64 in.² diaphragm top, it is possible to stroke the valve fully in 1·5 sec, without any tendency to oscillation. A high degree of stability is achieved because the relay incorporates an adjustable damping feedback circuit which permits tuning response to any particular circuit.

The relay will give a 10·3 s.c.f.m. average flow for 3–15 lb/in² change and 13·5 s.c.f.m. for 15–3 lb/in² change. When used with Sunvic's own valve positioner, 0·7% of full valve stroke causes 12 lb/in² valve pressure change. The relay can be used without a valve positioner when speed, but not positioning accuracy, is essential.

The model 61H will accept input pressure up to 100 lb/in² so that higher valve stroking speeds than those quoted above are possible. It will work in ambient temperatures from −40 to +180°F. Dead spot is within 0·05% of full scale; linearity within 0·4% of full scale and



The 6IH booster relay

reproducibility, when used with Sunvic valve positioner and with 4% valve friction, is within 0·1% of full scale. Maximum air consumption under balanced conditions is 0·5 s.c.f.m.

The relay is made by Sunvic Controls Ltd.

Tick No 177 on reply card

TORQUE MOTORS

with high output

A series of torque motors have been developed by the electronics division of de Havilland Propellers Ltd. The motors provide a mechanical energy output proportional to an electrical input signal. When unloaded a natural frequency of the order of 500 c/s can be expected, owing to the high ratio of internal stiffness to inertia. Hysteresis of the torque motors is normally 2% or less of output amplitude. Special models are available with hysteresis less than 0·7% but having a lower sensitivity.

As an example of the range the characteristics of one typical motor (B.00. DH.00 335) are given. Resistance and inductance are 510 ohms and 0·8H for each half winding. The maximum differential input current is 100 mA (value halved for series excitation). Maximum deflexion 0·13 rad. Optimum load stiffness 0 ± 1000 g-cm/rad. Nominal transducer stiffness 6500 g-cm/rad. Torque sensitivity (differential) 7·5 g-cm/mA, deflexion sensitivity (differential) 0·00092 rad/mA, hysteresis 2% of travel used.

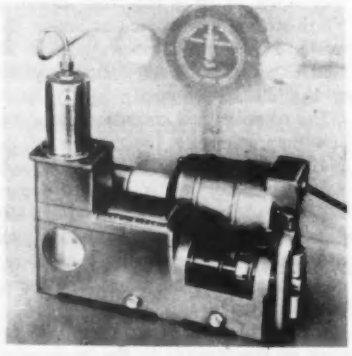
Tick No 178 on reply card

METERING PUMPS

improved operation

The DCL M-range of metering pumps produced by The Distillers Co. can now be provided with automatic control. developed primarily for the accurate metering of small quantities of fluids, the new range can be operated with pH, temperature, flow and other controls.

These automatically-controlled DCL M-pumps are responsive to pneumatic signals of from 3 to 15 lb/in² gauge, adjustment of the plunger stroke being carried out by a small, compact bellows motor operating through a mechanism designed to reduce hunting. Available with different plunger sizes giving a range of capacities from 0–750 cm³/h to 0–37·3 l/h, the pumps are suitable for working pressures up to a maximum of 2400 lb/in² gauge, the maximum pressure depending upon capacity. The output from each pump is proportional to the air pressure, the control gear being designed to give maximum capacity at either 3 or 15 lb/in² gauge. Power is provided by a 1/15 h.p. totally enclosed induction motor. The suction and delivery valves, both of which are duplicated, are



Pump controlled by temperature

of 12% chromium non-corrosive steel balls specially lapped to ensure high volumetric efficiency.

The present price of the standard M plunger pump is £95 ex-works, the M pump with stainless diaphragm head being £130. When fitted with the bellows unit for automatic control, the prices are £145 and £180 respectively, normal delivery being ex-stock.

Tick **No 179** on reply card

VALVES

some recent developments

A range of 2- and 3-way ductile iron valves have been developed for working pressures up to 600 lb/in.² at 400°F. The operating pressures on the diaphragm tops are 30–40 lb/in.² for valves at 600 lb/in.², and 15–30 lb/in.² for valves at 300 lb/in.² working pressure. Direct acting and reverse acting valves are in sizes ¼ to 3 in.

For air gas pressures of 5000 lb/in.² a range of valves is available in 2- or 3-way bodies, normally open or closed, in sizes ¼ to 3 in. The diaphragm operating pressure is from 35–40 lb/in.². The bodies are of aluminium bronze billet or alloy steel.

A range of diaphragm valve operators can be supplied for air pressures up to 110 lb/in.². The spring operator can be used for valves up to 3 in. in bore at medium working pressures. The outside diameter of the top is 5½ in.

All these valves are manufactured by Hunt & Mitton Ltd.

Tick **No 180** on reply card

ELECTRONIC COMPUTER

the smallest in Europe ?

A transistorized desk-size electronic digital computer is to be manufactured by Ferranti Ltd. Known as Sirius, Ferranti believe it to be the smallest and most economically priced computer yet made in Europe. The first production models will be available this Autumn, costing £15,000 with a delivery of 3 months from ordering.

Sirius weighs 5 cwt, measures 7 × 3½ × 4 ft and can be powered from an ordinary power socket. It works on a fixed-point decimal system in a serial mode. The words are 10 decimal digits long, each of 4 bits. The nickel delay lines each hold 50 words. There are 9 registers, held on single word delay lines, one of these is the control register and the others are X-registers or accumulators, all of which have full arithmetic facilities and any of which can be used as modifiers. All 8 accumulators and also the control register can be used as modifiers. There are usually 1000 storage registers (20 delay lines) but there are addressing facilities for up to 1,000,000 registers. Access to the accumulators is immediate, access to ordinary registers may take 4 msec.

The input is on 5-hole paper tape at a speed of 300 characters/sec. The output is on 5-hole paper tape at a speed of 33 characters/sec punching and 10 characters/sec for printing tape.

Addition or subtraction takes 240 μsec for numbers in X-registers and up to 4 μsec, depending on access time, for a number in a register. Multiplication takes a multiple of 4 msec, to to 16 msec depending on the numbers involved.

Tick **No 181** on reply card

The new Sirius digital computer

QUICK LOOKS

• A range of high stability transistorized power supplies is being marketed by Metrix Instruments Ltd. The power units are available with current ratings from 1–10 A at voltages from 0–30 V, with a stability of ±0·1% for models up to 2 A, and better than ±0·2% for 10 A models.

Tick **No 182** on reply card

• The Pochan-France densitograph is now available from Hunt & Mitton Ltd. It accurately measures density by a continuous method, and has an output which can be used for automatic regulation.

Tick **No 183** on reply card

A range of pressure reducing valves, in sizes from ¼ to 2 in., has been announced by Samuel Birkett Ltd. The valves are suitable for upstream pressures up to 250 lb/in.² for steam, or 300 lb/in.² for air or water, and operate at total temperatures up to 450°F. The maximum downstream pressure is 150 lb/in.² for the ¼ and ⅜ in. sizes and 125 lb/in.² for other sizes. Pressure alterations are made by simple screw adjustment.

Tick **No 184** on reply card

• A range of pneumatically-operated 4-way valves for the control of double-acting hydraulic valves has been produced by Hunt and Mitton Ltd. The valves are suitable for hydraulic working pressures from 200 to 3000 lb/in.² (non-shock) at temperatures up to 140°F, and are made in ¼, 1, 1½ and 2 in. sizes. A 300 lb. rating 4-way valve is also available in sizes ¼ and 1½ in. only.

Tick **No 185** on reply card

• An air control valve embodying a new system of diaphragm poppet actuation has been produced by Air Automation. The sealing is by neoprene diaphragms and gaskets, and maintenance requires only the loosening of four screws and the replacement of the neoprene elements.

Tick **No 186** on reply card

• A new 14-stage photomultiplier tube (type 56 AVP) has a transit time difference, under typical operating conditions, of 0·3 mμ sec—an improvement of about 100 times over normal tubes. Mullards claim their tube is the most advanced of its kind in the world. It has been designed for use where exceptionally high definition is required in scintillation counting and nuclear radiation spectrography.

Tick **No 187** on reply card

• Marconi Instruments have shown a circuit magnification meter (TF1245). This is a single Q-meter covering a range a.f. to v.h.f. (1 kc/s to 300 Mc/s). It permits direct measurement of Q-factors from 5 to 1000.

Tick **No 188** on reply card

CONTROL IN ACTION

Continuous tinplate production at Velindre

High-speed plating under automatic temperature control

The electrolytic tinplating of steel strip at the Velindre Works of the Steel Co. of Wales is under a degree of automatic control more usually associated with completely continuous processes. The base strip is first cold reduced in a five-stand tandem mill, and then cleaned and annealed either by an electrolytic method followed by batch annealing, or by a continuous annealing furnace with integral cleaning facilities. After annealing, the strip passes through two-stand temper mills, is side-trimmed and gauged, and fed to one of three electrolytic tinning lines.

All temperature control instrumentation as well as ancillary flow, pressure and other control instruments are by Honeywell Controls, their 'Electronik' principle, which uses electronic control units, being generally employed, although Air-O-Line pneumatic controllers are also used.

Electrolytic tinning line

The ½ lb line is at the left of Fig. 1, with its control panel at the right. The strip is cleaned in an electrolytic alkali bath, followed by rotary scrubbing and electrolytic pickling to produce a clean, etched surface for plating. Next it is plated and steam-dried and in the third, or 'reflow', stage a combination of muffle furnace and resistance heating melts the tin coating just sufficiently to produce a glossy finish. In the finishing section, the hot strip is cooled by water quench, passed through a neutralizing bath, is dried by steam and hot air, and a fine film of protective oil is electrostatically applied. The strip is then cut in a flying shear and packed straight off the line. A photo-electric device (Harland Drives and Simon Equipment) automatically rejects pinholed material, and an isotope thickness gauge (Davy United and Isotope Developments) similarly rejects off-gauge material.

Fig. 1 The ½ lb tinning line at Velindre

Instrumentation

Fig. 2 shows part of the control panel for this tinning line. Four circular scale instruments (top centre) indicate and control the temperatures in the chemical treatment system, the water quench tank, the pickle liquor circulating system, and the alkali system. The rectangular strip chart instuments (bottom row) comprise, from left to right, an eight-point recorder displaying temperature at different points in the chemical treatment system, a two-point instrument recording muffle furnace temperatures, and a six-point recorder showing temperatures in the electrolyte circulating system. The circular chart recorder (centre, bottom row) is a pneumatic liquid level controller for the electrolyte system. A circular chart instrument (top right) records coating thickness, derived inferentially from plating current and strip speed as measured by electric tachometer.

Most Honeywell instruments at Velindre operate on the continuous balance principle (Fig. 3). The output from the thermocouple or other sensing element, is applied across the converter-vibrator and the centre-tap of the input transformer. This voltage is normally balanced by the battery voltage across the slidewire, any net increase or decrease being converted by the vibrator to an alternating voltage across the transformer primary. The transformer output is amplified and applied to one phase of a two-phase balancing motor driving a pinion. The other phase is energized by the supply voltage, so that the direction of rotation of the motor is determined by the direction of unbalance. The motor moves the slidewire contactor in the direction and by the amount which will restore the circuit to balance.

The drive cable is connected to the indicator – in this case, the print-wheel carriage of the multiple recorder. Each thermocouple is automatically connected to the balancing unit at predetermined intervals, the print-wheel being turned at the same time to produce the required identifying symbol.

Electronic control

Ample power is available from the balancing motor for control action. The drive cable, which operates the print-

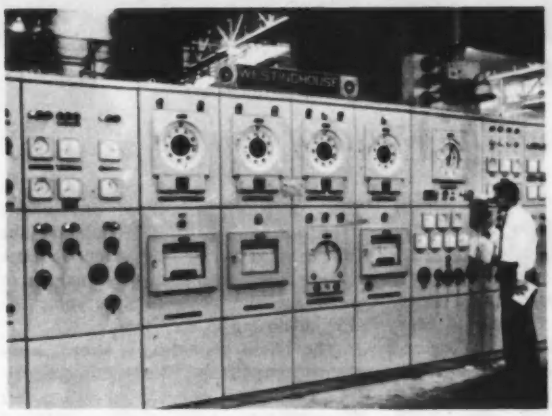


Fig. 2 Part of the control panel for the ½ lb line

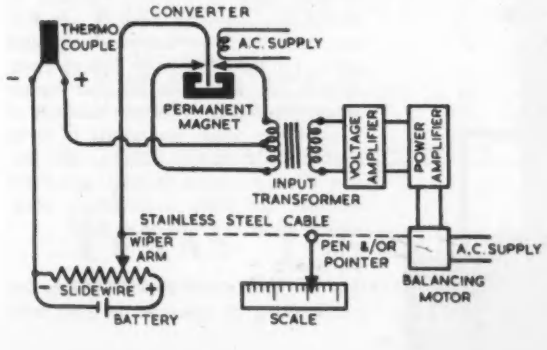
wheel or pen, can be used, for example, to tilt a mercury switch for simple two-position control, while proportional control is obtained by making the balancing mechanism operate a second slidewire potentiometer. This resistance forms part of a bridge circuit in which another variable resistance is driven by the motor operating the final control element – steam valves in the case of the various tank temperature controllers on the tinning lines, and motorized gas valves on the continuous annealing plant. Unbalance in the measuring circuit alters the first resistance to unbalance the bridge in such a direction that the control motor moves to correct the controlled variable. In doing so, the second resistance is varied to re-balance the circuit.

Pneumatic control

The same measuring circuit may also be coupled to a pneumatic control system. In the Air-O-Line controller the balancing motor is connected through a linkage to a pneumatic balancing unit operating on the standard 3-15 lb/in² compressed air system. The output pressure of the controller is proportional to the amount of deviation from the desired valve and may be used to operate a diaphragm valve, or similar equipment, to exert the required control action.

The liquid level in the electrolytic circulating system tank is recorded and controlled by the circular chart instrument in the bottom row in Fig. 2. The sensing element is a sealed diaphragm unit, incorporating a nozzle and flapper bleed system fed from the pneumatic mains, which produces an output pressure proportional to liquid head.

Fig. 3 Honeywell's continuous balance principle



The control element is a diaphragm valve in the recirculation circuit.

The same controller can also be used for flow control, a Honeywell differential converter producing a pneumatic signal proportional to the pressure drop across an orifice plate. Temperature can be sensed by thermocouple, using an electro-pneumatic transmitter to convert its output to the required 3-15 lb/sq. in. pneumatic signal.

Continuous and batch annealing

Similar basic control systems are employed to supervise all the processes at Velindre. One of the more spectacular is the continuous annealing line. The furnace consists of five vertical passes, divided into 10 gas-heated zones, each zone individually controlled, followed by a soaking zone comprising two electrically-heated passes divided into four controlled sections. Controlled cooling follows, the strip passing through air-cooled and water-cooled sections.

All sections are controlled by Electronik recording instruments, using proportioning motors on the gas valves with on-off control of the electrical elements through mercury switches mounted on motorized step-controllers. Cooling is adjusted by a butterfly valve in the air exhaust. The valve is under proportional control, the sensing element being a Radiamatic pyrometer reacting to strip temperature.

In the batch-annealing section, each of the 14 furnace bases accommodates eight stacks of coils, every stack being surrounded by a muffle into which is piped a protective atmosphere to prevent oxidation of the strip. The seven

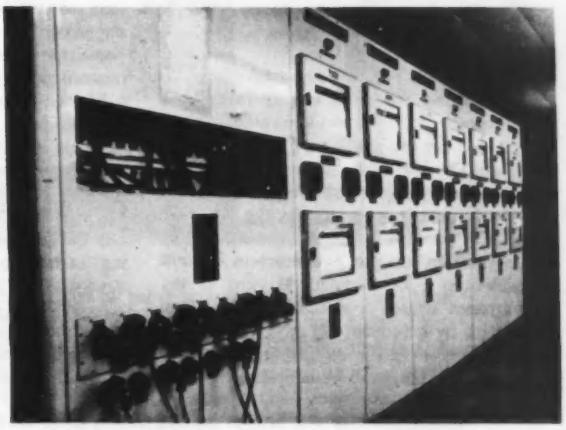


Fig. 4 Batch annealing is controlled from this panel

furnace covers, any one of which may be lowered by crane over any base, are gas-fired with motorized valves controlled by the panel shown in Fig. 4. On each furnace base there are 12 thermocouples, those on the seven bases in use at any given time being connected to the seven recorders in the lower row in Fig. 4. Each recorder thus displays temperature values at 12 points, eight at the base of the coil stacks while the remaining four, which are fitted to flexible extensions, measure temperatures higher up the stack.

The upper row of instruments in Fig. 4 comprises three-point temperature controllers. One point provides overriding control of temperature in response to a thermocouple mounted in the roof of each furnace cover; the other two points provide local control of temperature in the two halves of each furnace in response to any two of the 12 thermocouples in the base.

NEWS ROUND-UP

from the world of control

——CHEMICALS——

Shell Haven fertil'er plant

CONTROL attended the official opening of the Shell Chemical Company's new fertilizer plant at Shell Haven, Essex, recently and took the opportunity of seeing the plant. Here air, oil and chalk are used to make ammonia, nitric acid and an ammonium nitrate/chalk fertilizer known as 'Nitra-Shell'. At present, the plant has a capacity of 75,000 tons of ammonia a year, 60,000 tons of which will be sold as such and the balance, 15,000 tons, will be used to produce some 60,000 tons of Nitra-Shell.

Sixteen gas analysers

The plant is heavily instrumented with equipment and controls of the type normal to oil refinery operation. To us, however, the most striking feature was that 16 gas analysers of various types are employed on the plant. Many of these provide 'high' level alarms.

VPC, Hirsch cell and paramagnetic

The first process is air separation into nitrogen, for ammonia synthesis, and oxygen for use in the oil gasification process. The air intake must not be contaminated by hydrocarbons—the oil refinery is on the same site as the chemical plant—so vapour phase chromatography is used to analyse hydrocarbon content down to 1 or 2 p.p.m. Oxygen in the nitrogen stream is detected at around 60 p.p.m. by a Hirsch cell oxygen analyser, and oxygen in the oxygen stream (95%) by a paramagnetic instrument.

Infra-red

Five infra-red methane analysers are used in the partial oxydation unit. Here, hydrogen for the ammonia synthesis is derived from gas prepared from fuel oil —any feedstock from methane to heavy fuel oil may be used. The hydrogen is produced in five reactors whose outputs are analysed separately for methane by five infra-red analysers.

Electrical conductivity

The raw gas from the partial oxydation section contains up to 1% of hydrogen sulphide and this is reduced down to about 0·01% in a phosphate treater. An electrical conductivity hydrogen sulphide analyser confirms this. From the phosphate treater the synthesis gas passes to a carbon monoxide converter which reduces the carbon monoxide to a low figure but also increases the hydrogen sulphide level to about 0·05%. This is reduced to a negligible value by oxydation to sulphur, which entails adding oxygen to the crude hydrogen stream. A paramagnetic oxygen analyser checks the amount of oxygen.

The next process is removal of carbon dioxide from the stream, an infra-red analyser detecting the amount of carbon dioxide present. Final purification by scrubbing with liquid nitrogen removes any carbon monoxide, methane, argon and oxygen, an infra-red analyser detecting carbon monoxide in the hydrogen stream down to 1 or 2 p.p.m.

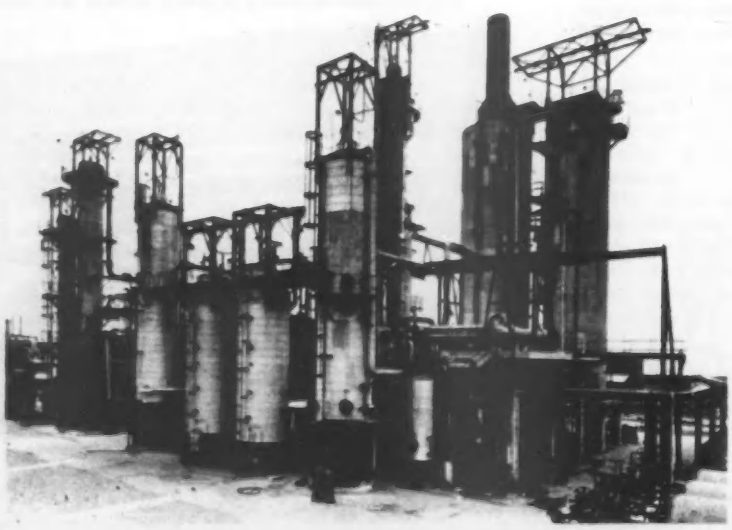
Thermal conductivity

The pure hydrogen, mixed with a proportion of pure nitrogen, passes forward to the ammonia synthesis section, at the inlet of which a thermal conductivity type hydrogen analyser monitors the stream. This section consists of two loops with a thermal conductivity analyser in each, the aim being to have some 70–75% hydrogen in each loop.

The liquid ammonia, is stored, some being pumped to Fisons Ltd., nearby. Measurement is normally by flow meters, a weigh tank checking the accuracy of these periodically.

Nitric acid is produced from ammonia by first oxydizing the latter over a catalyst and then absorbing the oxides in water to yield nitric acid. The ammonia vapour is mixed with primary air before entering the reactor and a thermal conductivity ammonia-in-air analyser checks this.

The synthesis gas purification section of the Shell Chemical Fertilizer Plant



——ATOMIC ENERGY——

Control engineering at Dounreay

A control engineering development group has been set up by the UKAEA at Dounreay, under L. Tweeddale, formerly of the Ministry of Supply (General Missiles), to deal with the development of remote control processes for plutonium fuel element development, fabrication and examination. The Group will also develop suitable control instrumentation for the chemical laboratory and plant. The work involved concerns many of the techniques covered in CONTROL particularly the remote control of machine tools and production processes. To some extent, however, the work differs in that remote control is primarily required for the protection of personnel from radiation hazards rather than for the economic advantages to be gained from mass production. Since the products are in small batches of varying designs as development proceeds, flexible and adaptable control systems are required.

Remote control of robots

In these columns in April, CONTROL reported that American Babcock and Wilcox have built six remotely-controlled robots for the US Atomic Energy Commission. We have now received further details from B & W of the methods of transmitting coded commands to these remote maintenance vehicles. At present a radio system is used, but three methods are being considered: ultrasonics, radio and induction loop.

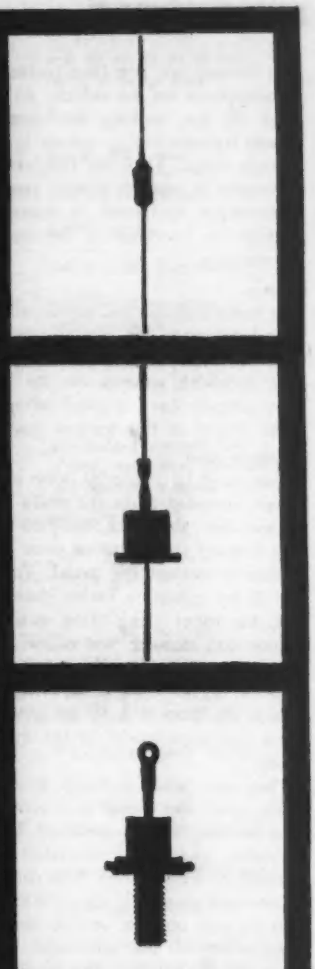
Ultrasonics

In this system, the signal would be fed into a string of speakers, or other suit-

SILICON RECTIFIERS

up to 600 Volts P.I.V.

3 amps



TEXAS SILICON RECTIFIERS offer excellent high temperature characteristics. For example the stud-mounted type gives an output of 3 amperes at 50°C and will still provide 1 ampere at 150°C with no change in the rated peak inverse voltage. The rugged, welded housing with glass-to-metal seal provides high resistance to shock and vibration. Listed in the table below are the characteristics of representative devices of each type.

Have you received your copy of the latest Texas Application Report "D.C. Power Supply Circuits using Silicon Rectifiers"? If not, or if you require fuller details of Texas Rectifiers, please write your name and address in the margin and return this advertisement to us.

	Symbol	1S001	1S005	1S111	1S115	1S401 1S401R	1S405 1S405R
MAXIMUM RATINGS							
Peak Inverse Voltage at −65°C to +150°C	PIV	200V	600V	200V	600V	200V	600V
Average Rectified Forward Current at +50°C	I_o	750mA	750mA	† 400mA	† 400mA	*3A	*3A
Average Rectified Forward Current at +150°C	I_o	250mA	250mA	150mA	150mA	*1A	*1A
Recurrent Peak Forward Current at +50°C	i_j	† 2·5A	† 2·5A	† 1·25A	† 1·25A	*10A	*10A
Surge Current for 10 Milliseconds	I_{FK}	16A	16A	6A	6A	33A	33A
Operating Temperature, Ambient	T_A	−65°C to +150°C					
SPECIFICATIONS							
Minimum Breakdown Voltage at +150°C	V_R	240V	720V	240V	720V	240V	720V
Maximum Reverse Current at P.I.V. at +25°C	I_{Lb}	10μA	10μA	0·2μA	0·2μA	10μA	10μA
Maximum Forward Voltage Drop at +25°C	E_b	1·0V (I_b=500mA)	1·0V	1·0V (I_o=400mA)	1·0V	1·1V (I_b=1Amp)	1·1V

* Rectifier mounted on 2" x 2" x ⅛" aluminium Heat Sink † @ 25°C

TEXAS INSTRUMENTS LIMITED

TELEPHONE: BEDFORD 68051 DALLAS ROAD BEDFORD CABLES: TEXINLIM BEDFORD

able transducers, and then picked up by a microphone on the vehicle. At present B & W are looking for components (sound transducers) to operate in the 20–90 kc/s range. They are conducting experiments in the 10–20 kc/s range with a prototype equipment in order to determine the feasibility of this method of transmission.

Radio

In radio control, the signal would be modulated on a low power r.f. carrier, fed into an antenna system, and radiated to a receiving antenna on the vehicle. They already have a small seven command model of this method under test.

Induction loop

Command by induction loop employs signals provided as in the radio control method, but these are fed into a wire loop around the operating area instead of into a transmitting aerial. Transmission is by induction rather than radiation, the robot being fitted with an induction coil receiver. The vehicle can receive commands anywhere within the loop but signal strength falls off rapidly outside the loop. B & W are now building a prototype model of the induction system.

They are also building a receiver which, once the signal is received and demodulated, will be common to all—ultrasonic, radio and induction loop—methods of transmission. This consists of a two-stage amplifier, discriminating circuits to sort out the various frequency components of the command, and a diode matrix decoder. The receiver will operate relay contacts to control motor starters and solenoid valves on the vehicles.

TIMBER

Saw mill control

An interesting application of control at the Worksop saw mill of Godley and Goulding Ltd., timber merchants, is reported by Westool Ltd., of St. Helens. The problem was to autocontrol a log carriage which carried logs (up to 25 ft long and 4 ft dia) into the saw. Previously, a manually-operated rachet drive was used to move the log sideways and set the thickness of the board to be cut between ¼ in. and 3 in. It was decided to drive the cross traverse feed with a ½ h.p. motor using a clutch brake coupling.

Potentiometer positioning

A control station carries forward, reverse and stop controls for the traverse motor, and also start and stop controls for the clutch and brake. Two potentiometers, one coarse (1–5 in.) and one fine, control the cutting widths. These bias a thermionic valve. On engaging the traverse clutch, a further clutch is also engaged to couple the traverse drive shaft to a position-indicating potentiometer through gear reduction and a coil spring. As this shaft turns (carrying the log sideways) the potentiometer is turned until it reaches a setting that cancels out the bias on the electronic valve. The latter 'fires' and energizes a relay which disengages the traverse and potentiometer clutches and applies the brake. The spring-loaded potentiometer then returns to the zero position ready for the next cycle.

The entire sequency is automatic and is said to provide a board thickness accurate to ±1/64 in.

CARS

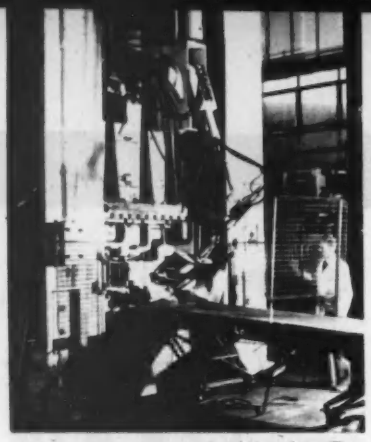
Vauxhall's press shop

Automatic loading, ejecting, extracting, and transfer equipment operated by compressed air is a feature of the new press shop at Vauxhall Motors, Luton, which a CONTROL reporter visited. The systems include 'iron hand' devices for extracting pressings from the dies and placing them on inter-press transfer units or conveyors, tension breaking ejectors and side-lancing equipment mounted within the presses, and automatic loading, pre-bending and turnover machines. The equipment, which is by Holman Group member, Maxam Power Ltd., consists essentially of a system of valves and air cylinders, remote controlled and synchronized with the stroke of the press. It is suggested that Vauxhall's use of these automatic systems will lead to a saving of 153,000 man hours a year, plus higher safety standards.

Iron hand extraction

Automatic jaw extractors are mounted at the rear of all presses up to 1500 tons capacity. These move forward to grasp a pressing and lift it clear of the die immediately the press ram moves upward. The jaw unit is then moved outward from the press and, at the completion of the stroke, opens to release the pressing on to a conveyor or turnover machine. The jaw arm then returns to its original position.

At the beginning of the cycle, the arm is at rest and the jaw open. On completing a pressing the press ram rises and a rotary cam-operated microswitch closes to energize a solenoid valve. This passes air to the jaw unit cylinder causing the piston to move forward and, simultaneously, air is fed via restrictors and reservoirs to two other cylinders. After a delay (0–7 sec) one cylinder raises the jaw unit and the pressing is lifted clear of the die, and the other moves the arm away from the press. As the arm moves out, a second microswitch is tripped to de-energize the solenoid valve. After a delay air escapes through the reverse restrictor valves, and the arm returns.



An inner door panel is removed from a press at Vauxhall Motors by an automatic, pneumatically-controlled jaw extractor

Ejection and side lancing

Pressings tend to adhere to the lower dies and ejection is achieved by means of air cylinders in the dies, which operate when the rotary cam-operated microswitch has energized a solenoid valve. Before the next sheet is loaded, the switch operates again, de-energizing the solenoid valve and causing the air cylinder pistons to retract.

Side lancing is carried out in similar fashion. Air cylinders built into the presses carry lancing punches mounted at 90° to the surfaces to be lanced. This means that a single press can perform side lancing while a pressing is being formed.

Loading, pre-bending and turnover

Full use is made of mobile pneumatically-operated loading stations of various types, and of pre-bending and turnover machines. The principle of operation is much the same for all these machines: they all operate by Maxam cylinders, valves, microswitches and bleed reservoir units, etc., controlled electrically by the rotary cam-operated switch and synchronized with the stroke of the press.

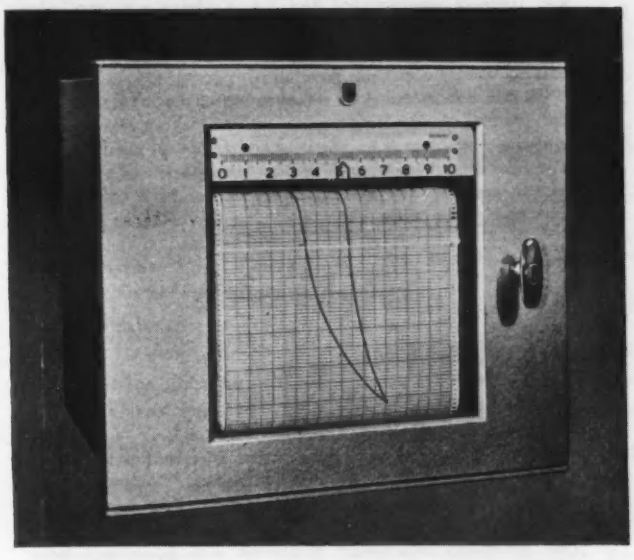
The press shop covers nearly 210,000 sq ft and houses 222 new presses. It forms part of the £36 million expansion and modernization programme for the Luton and Dunstable factories, which Vauxhall Motors completed recently.

COMPONENTS

Transistor technology

The 1960 Solid State Circuits Conference, sponsored by the IRE, the AIEE and the University of Pennsylvania will be held in Philadelphia on February 10–12, 1960. Applications and circuit techniques of a great variety of solid state devices will be covered, and the Conference Committee (Chairman: Arthur P. Stern, General Electric Company, Electronics Laboratory, Electronics Park, Syracuse, New York, USA) emphasize international participation. Papers are solicited, and abstracts of 300 or more words required, by Tudor R. Finch, Chairman, Programme Committee, 1960 Solid State Circuits Conference, Bell Telephone Laboratories Inc., Murray Hill, New Jersey, USA.

NOW...



'X-Y' RECORDER

by PHILIPS

Philips X-Y recorder PR.2220A/00 records the relationship between two variables which can be represented by small D.C. voltages. The unit consists of two completely independent measuring circuits operating on the automatic zero balancing principle, in which the pen is operated by one of the circuits and the chart drive by the other. Leaflet IM4-A12 gives full technical details — write for your copy now.

Sole distributors in U.K.:

X-Y RECORDER TYPE PR.2220A/00

Zero-point position	*at 0, 20, 40, 50, 60, 80 and 100% of the full scale*
Accuracy	*0.5%*
Balancing force	*Approx. 300 grams.*
Damping of the servo-system	*critically adjustable.*
Bridge current	*1 mA ± 0.1%.*
Amplifier	*A.C. amplifier, plug-in type.*
Permissible input impedance	*400Ω/mV of measuring range selected**
Permissible D.C. voltage across input terminals and earth	*1000 x span, 100 V maximum**
Permissible A.C. voltage	*across input terminals 0.001 x span; across input terminals and earth 100 x span**

** Criterion of reproducibility 0.1%.*

Y-CHANNEL

Direction of pen movement	*horizontal.*
Graduation of scale	*linear from 0 to 100.*
Length of scale	*250 mm.*
Balancing time	*1 sec. for full scale deflection.*

X-CHANNEL

Chart travel	*vertical upwards or downwards.*
Scale	*preprinted strip chart.*
Length of X-axis	*250 mm: after change of transmission ratio 360 mm.*
Response time	*2 sec.*
Recording unit	*ink container and capillary stylus for 0.3 mm line width: tear-off arrangement for recorded diagrams.*

MEASURING RANGES Y-CHANNEL	X-CHANNEL
0..... 5 mV	
0..... 10 mV	
0..... 20 mV	0..... 20 mV
0..... 50 mV	0..... 50 mV
0.....100 mV	0.....100 mV
0.....200 mV	0.....200 mV
0.....500 mV	0.....500 mV

The Philips X-Y Recorder is a Product of N.V. Philips, Eindhoven.

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(RCL0403)

RAILWAYS

BR – Elliott Track Recorder

Control travelled recently in British Railways' track recording coach, a four-wheeled Diesel vehicle by Elliott Bros. (London) Ltd., which provides accurate data on the profile of a loaded track. For the measurement of cant (superelevation) a datum is provided by a high speed gyroscope which enables the vehicle to operate at up to 30 miles/hour regardless of curvature or gradient.

Curvature and gauge are obtained by measuring the movements of a system of probes which contact the inside edge of the head of the rail. Measurements are presented as visible traces on Kodak photosensitive paper in the multi-channel recorder which employs reflector type galvanometers. At the same time as the record is being made a previous chart, taken over the same piece of track, can be viewed on an adjacent display. This comparison enables any deterioration to be seem immediately.

Gauge and curvature

For the measurement of gauge and curvature, the probes are carried from a lattice girder framework supported at the axle boxes, the points of support of this framework being arranged to give the necessary degrees of freedom to allow

Main control panel (left), multi-channel recorder (right) and driver's position (centre) of the BR-Elliott track recording coach.

the axles to twist relatively in both vertical and lateral planes. The sensing probes are spring-loaded against the rails and guide shoes, running in the opposite flange way, ensure their passage through gaps at points etc. The probe is a sensitive detecting element of low inertia giving immediate and accurate response to any deviation from line or gauge. When operating, the probes are held down by compressed air and can be withdrawn, clear of the track, when not in use. Raising and lowering is controlled through solenoid-operated valves.

Superelevation

Cant is measured by comparing the position of one of the axles with a datum provided by the gyroscope mounted immediately above this axle. The spin of this gyroscope axis is maintained horizontal across the coach at all times. Correcting torques are applied to balance the effect of the earth's rotation and to allow for the movement of the vehicle around curves. The use of a gyroscope avoids the significant errors which can occur if a pendulum is used as a datum.

Measurements of curvature, gauge and cant are obtained as a.c. signals from synchro type pick-offs. These signals are linearly demodulated and the resulting a.c. applied to mirror galvanometers. The record is produced by these galvanometers on photographic paper by the reflected beams from an ultra-violet light source.

In addition to the main measurements, the record includes the speed of the vehicle, distance marking, facilities to indicate events such as stations and space for making notes. The new record together with the 'play-back' of a previous record are both fed through the recorder by a drive taken from one of the axle-boxes; a choice of scales is provided.

GUIDED WEAPONS

Seaslug a beam-rider

The method of guidance of the Royal Navy's Seaslug ship-to-air missile has now been released: it is a 'beam-rider'. A ship borne tracking radar illuminates the target aircraft with a narrow beam of radiation. The radar locks on to, and follows, the target regardless of any evasive action, and the missile is fired along the axis of the beam. The guidance equipment evaluates any positional error which the weapon may have with respect to the centre of the beam, correcting signals actuating the appropriate fin movements to steer the missile towards the centre. Seaslug is by Armstrong Whitworth Aircraft, with guidance by GEC and control by Sperry and great claims are being made for its accuracy.

OIL

CERES for BP

Control Engineering Research Electronic Simulator (CERES) has been ordered by British Petroleum from Air Trainers Link. It will be used to simulate conditions in various fields of refining operations so that automatic control systems and plant designs can be studied and developed. In addition, such problems as plant economics will be studied, stress and vibration analyses made and operator training carried out. Typical and exceptional situations which may occur in controlled refining processes will be simulated.

Each element of the analogue computor is designed for 0.1% accuracy; 48 d.c. amplifiers are used and chopper stabilizers ensure that the long term input drift is below 100 microvolts, while the open loop gain and frequence response are claimed adequate for accuracy under the fastest operation envisaged. The 92 coefficient potentiometers will be set up manually, although automatic pot-setting may be incorporated later. Fast and slow response servo-multipliers are employed, the latter being suitable for long-term integration – process simulation over many hours.

Air Trainers suggest that CERES could lead to a new approach to automatic control of processes: the use of on-line analogue, rather than digital, computors.